B. Specification

Please amend the paragraphs at page 1, line 6, through page 3, line 16 as follows:

The present invention relates to a substrate for an ink jet head having a protective element for electrically protecting internal ~~elements, which is a~~ elements. The substrate is used for an ink jet head operable to record by discharging ink droplets from discharge ~~ports,~~ ports. The invention is further directed to an ink jet head having such a substrate for the ink jet ~~head,~~ head and an ink jet head recording apparatus having such an ink jet head.

Related Background Art

Conventionally, ~~there has been known~~ an ink jet recording method of recording on a recording medium (papers in most cases) ~~by discharging and flying~~ via discharge and flow of ink droplets from discharge ports is known. This ink jet recording method, which is a non-impact type recording method, has recently been popularized rapidly because it has ~~characteristics of less~~ relatively low noise generation ~~of noise~~, is capable of recording directly on a paper, and also is capable of easily recording color images by using multi-colors of ink. Among a variety of recording methods, particularly known is that of forming ink bubbles by applying thermal energy to ink responsive to recording signals and then, with an action force generated thereupon, discharging and ~~flying~~ flowing the ink from discharge ports. This method has an advantage in that an ink jet head with high density multi-nozzles capable of providing high-resolution high-speed recording may be easily realized and obtained.

An ink jet head used for this recording method is, in most cases, provided with a number of discharge ports for discharging ink, liquid channels each of which is provided for the discharge port and is ~~communicated~~ in communication therewith, and a common liquid chamber for stably supplying ink into each liquid channel. This ink jet head utilizes thermal energy generated when a heater is energized through a driver, and thereby discharges ink delivered from the liquid channels from the discharge ports for a recording operation.

Such an ink jet head is so constituted, for example, that a substrate for an ink jet head is joined to a top plate on which is formed liquid channels, a liquid chamber, discharge ports, and the like. The substrate for an ink jet head comprises heaters (heating elements) for generating thermal energy to discharge ink, drivers for driving these heaters, a logic circuit for controlling the drivers, a substrate temperature sensing element for sensing substrate temperatures, a pad unit for electrically connecting the ink jet head and an ink jet recording apparatus with each other, and the like. The heaters are formed at positions corresponding to respective discharge ~~ports;~~ ports and so arranged that the number of ~~the~~ heaters may be compatible with that of the discharge ports. Therefore, the drivers are formed compatibly with the number of ~~the~~ discharge ports. Such a substrate for an ink jet head is monolithically fabricated of a silicon semiconductor substrate according to semiconductor device manufacturing techniques. Particularly in the substrate for an ink jet head, since discharge properties of ink droplets discharged from the discharge ports in the ink jet head and substrate temperatures are closely related to each other, sensing of substrate temperatures is given a relative importance.

Please amend the paragraphs at page 5, line 6, through page 6, line 3, as follows:

More specifically, the substrate for an ink jet head in the present invention has a plurality of heaters for discharging ink, a drive circuit for driving the plurality of heaters, and a substrate temperature sensing element for sensing substrate temperatures, all of which are formed on the same ~~substrate, and~~ substrate. The substrate is characterized in that a protective element is provided between the substrate temperature sensing element and a connection pad which is electrically connected with the substrate temperature sensing element and which establishes electrical connection with external components.

An ink jet head in the present invention is characterized by comprising the substrate for the ink jet head described ~~above,~~ above and a member for forming a liquid channel jointed to the substrate for the ink jet head and associated with the heater and also for forming an ink discharge port which belongs to one end of the liquid channel.

An ink jet recording apparatus in the present invention is characterized by comprising the ink jet head according to the present ~~invention,~~ invention and means for applying signals to the connection pad to acquire information about head temperature by supplying the signals to the connection pad.

Please amend the paragraph at page 6, line 27, through page 7, line 2, as follows:

FIG. 7 is a diagram schematically showing a constitution of an ink jet head using the substrate for an ink jet head shown in ~~FIG. 1~~FIG. 1;

Please amend the paragraphs at page 7, line 26, through page 11, line 6 as follows:

This substrate for an ink jet head (element substrate) 21, which is formed on ~~(built-in)~~ (built-in) a silicon semiconductor substrate using semiconductor device manufacturing techniques, has a substantially rectangular shape and includes a through hole functional as an ink supply port 20 extending in a longitudinal direction, which is formed in the center of the substrate 21 in the drawing. Along two sides of the ink supply port 20, a plurality of heaters 24 is arranged. Each of the heaters 24 heats a liquid (ink) supplied from a rear side of the drawing sheet of the substrate for an ink jet head 21 via the ink supply port 20 to form ~~bubbles,~~ bubbles and discharges ink droplets from discharge ports (not shown in FIG. 1) arranged facing the heaters 24 (recording elements). On an opposite side of the ink supply port 20 across the heaters 24, a driver unit 25 is provided. The driver unit 25 includes drivers and others for driving each heater 24. Each of the drivers is typically provided for the respective heaters 24 and is composed of transistors for switches and others. Furthermore, the substrate for an ink jet head 21 has a logic circuit unit 23 and a pad unit for supplying power source and signals to this substrate for an ink jet head from a main body of a recording apparatus. The pad unit includes a plurality of pads 22 for routing wirings to the outside of the substrate by using electrical connection means such as wire bonding to electrically connect the ink jet head with the ink jet head recording apparatus. The logic circuit unit 23 includes logic circuits for controlling, when signals are given by the main body of the recording apparatus via the pads 22, ON/OFF of each transistor in the driver unit 25 responsive to the signals. Moreover, the substrate for an ink jet head 21 has a temperature sensor 26 composed of a diode sensor to monitor substrate

temperatures reflecting head temperatures from the apparatus main body side. The apparatus main body supplies signals to the temperature sensor and receives signals reflecting temperatures outputted from the temperature sensor.

The ink jet head having such a substrate for an ink jet head 21 is controlled when the logic circuits in the logic circuit unit 23 ~~performs~~ perform ON/OFF operations of transistors, i.e., drivers in the driver unit 25 upon receipt of signals inputted to the substrate for an ink jet head 21 via the pads 22. And when the heater 24 corresponding to the transistor being turned ON is energized, the heater 24 is warmed up, ink (liquid) on the heater 24 is heated to thereby rapidly generate ink bubbles, and consequently the ink is discharged from the discharge ports.

Next, the diode sensor in the substrate of an ink jet head according to the embodiment will be described.

FIG. 2 is an equivalent circuit diagram showing the case where a typical diode sensor 11 is connected from an input/output pad ~~as they are~~. Conventionally, the diode sensor 11 for sensing a temperature has been used for extremely simple connection such that anode and cathode of the diode sensor 11 are respectively connected to a pair of input pads. In this case, when static discharge is applied to the ink jet head, a large current i due to this static discharge flows into the substrate for an ink jet head 21 from a contact portion of the ink jet head via the pads 22 of the substrate for an ink jet head 21. The large current i flowing into the substrate 21 is all applied to elements themselves of the diode sensor, occasionally resulting in breakdown of the elements.

The substrate for an ink jet head 21 of the present invention is provided with protective diodes 32 as a protective element on respective anode and cathode ~~side~~ sides of

the diode sensor 26 as shown in FIG. 3. The protective diodes 32 are disposed between the anode of the diode sensor 26 and a power source line, between the anode and a ground, between the cathode and the power source line, and between the cathode and the ground, respectively. In this case, the ~~protect~~ protective diodes are so arranged that the anodes of the protective diodes connected to the ground side may be connected to the ground, and the cathodes of the protective diodes connected to the power source line side may be connected to the power source line, on condition that the power source in the substrate for an ink jet head is a positive power source.

Please amend the paragraph at page 12, lines 7-13, as follows:

More specifically, in a state shown in FIG. 2, the diode sensor element breakdown occurs under static electricity applied voltage of 2 kV on a contact discharge condition (discharge resistor 330 Ω, discharge condenser 150 pF). However, it does not ~~occurs~~ occur by employing the configuration shown in FIG. 4 under the applied voltage lower than 4 kV.

Please amend the paragraphs at page 13, line 7, through page 14, line 7, as follows:

The wiring width between the input pad 22 and the protective element 32 may be 8 mm or wider, more preferably, 10 mm or wider. This makes it possible to obtain a configuration resistant enough to the large current before its dispersion and escape to the

power source. Such a configuration achieves further ~~improvements~~ improvement of the breakdown resistance against static electricity.

The substrate for an ink jet head 21 is manufactured using semiconductor device manufacturing techniques as described above, and thus the logic circuit unit 23 and the driver unit 25 have substantially the same configuration as that of a semiconductor integrated circuit. Therefore, the substrate for an ink jet head 21 adopts a multi-layer wiring configuration. In the case where the wiring between the input pad 22 and the protective element 32 ~~is intersecting~~ intersects with another wiring layer, a step is formed at ~~an~~ the intersecting portion. If the large current i due to static discharge passes through such a step, wiring breaks may occur at the step in the wiring intersecting portion. Therefore, it is preferable that, as shown in FIG. 6, a wiring portion (indicated by a broken line in the drawing) between the pad 22 and the protective element 32 has no steps formed by intersecting wirings. This makes it possible to further enhance the breakdown resistance against static discharge.

Please amend the paragraphs at page 14, line 17, through page 17, line 22, as follows:

As is described above, on the substrate for an ink jet head 21, the plurality of heaters 24 are linearly arranged, which ~~generate~~ generates heat by receiving electric signals to discharge ink from the discharge ports 40 by bubbles formed by the heat. Channels 41 for supplying ink to the discharge ports 40 provided at positions facing respective heaters 24 are arranged corresponding to each of the discharge ports 40. These discharge ports 40 are formed on an orifice plate 101. By connecting the orifice plate 101

to the foregoing substrate for an ink jet head 21, a common liquid chamber is provided, which is ~~communicated~~ in communication with the ink supply port 20 and supplies ink to each channel 41.

FIG. 8 shows an external appearance of one example of the ink jet head. On a TAB tape 200, an electrical connection unit 201 with the substrate for an ink jet head 21 is provided, and on one end side of the TAB tape 200, a contact pad unit 204 used for connection with the recording apparatus is formed. The substrate for an ink jet head 21 of the present invention is disposed under the orifice plate 101. To the substrate for an ink jet head 21 on which the channels 41 are formed with a dry film or the like, an orifice plate 101 is attached, and thereafter it is joined to an ink tank 203 having the TAB tape 200 attached thereon, which is followed by bonding. Then, the electrical connection unit 201 in the TAB tape 200 is sealed by a sealing material to bring the ink jet head to completion.

This ink jet head is ~~detachable,~~ detachable and therefore may be touched with human hands. This means there is the possibility that static discharge may be applied from the contact pad unit 204. When the static electricity is applied to the contact pad unit, the applied static electricity is discharged as far as the substrate for an ink jet head 21 via the TAB tape 200.

FIG. 9 shows an external appearance schematically showing an ink jet recording apparatus IJRA to which the ink jet head of the present invention is applied.

A carriage HC, which is engaged with a helical groove 5004 of a lead screw 5005 that is rotated interlockingly with forward reverse revolution of a drive motor 5013 via driving force transmission gears 5009, 5011, is removably mounted with the ink jet head, has a pin (not shown), and is reciprocated in directions of arrows a and b. A sheet

press plate 5002 presses a print medium (in several, a paper) against a platen 5000 which is a print medium conveying means, over the entire range of movement of the carriage HC. A photocoupler 5007, 5008 is a home-position detector for performing switching of the direction of revolution of the driving motor 5013 by ascertaining the presence of a lever 5006 of the carriage HC within the above-described range. A member 5016 supports a cap member 5022 for capping a front surface of the ink jet head, and suction means 5015 sucks the inside of the capped portion in order to perform suction recovery of the ink jet head via an opening 5023 in the capped portion. Reference numeral 5017 denotes a cleaning blade, and reference numeral 5019 denotes a member which allows the movement of the cleaning blade in forward and reverse directions. Both the cleaning blade 5017 and the member 5019 are supported on a supporting plate 5018. It is to be understood here that the cleaning blade is not limited to the illustrated type, and well-known cleaning blades are definitely applicable to this embodiment. A lever 5021 initiates suction for suction ~~recovery,~~ recovery and is moved in accordance with the movement of a cam 5020 which is engaged with the carriage HC. A driving force from the driving motor is controlled for this movement via a known transmission mechanism, such as clutch switching or the like.

Each of these capping, cleaning and suction recovery means is configured so that desired processing can be performed at a corresponding position by the operation of the lead screw 5005 when the carriage HC reaches a region at the home position ~~side,~~ side and can be applied to this embodiment providing that a desired operation is performed at a well-known timing. Each constitution in the foregoing is an excellent invention in ~~terms of single one~~ and of itself, as well as their combination, and is shown ~~with~~ as preferable examples of the present invention.